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ABSTRACT

The purpose of this electrical program is to prepare students for service, repair, and assembly of electrically driven or controlled devices. The program theory and application includes mechanical assemblies, electrical circuitry, and electronic principles including basic digital circuitry. The electrical program manual includes the following sections: (1) general objectives for grades 10, 11, and 12; (2) a list of 41 major curriculum areas; (3) competencies for each area; (4) a curriculum outline for each area; (5) student progress records forms; and (6) 26 references. The apprentice-related curriculum manual in the second part of this document is intended to meet the requirements for achieving journeyworker status and a company's apprentice training requirements. Twenty apprentice program classes are outlined in this manual. Each course outline includes: (1) length in hours; (2) description; (3) competencies; (4) material covered; (5) textbooks needed; and (6) resources needed. (NLA)

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ELECTRICAL

CURRICULUM

PREPARED BY EASTCONN
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NORTH WINDHAM, CT 06256

PREPARED FOR:

CONNECTICUT STATE DEPARTMENT OF EDUCATION
DIVISION OF VOCATIONAL, TECHNICAL AND ADULT EDUCATION
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PROGRAM DESCRIPTION

Electrical workers are responsible for assembling, installing, and maintaining electrical systems. They also use handtools such as screwdrivers, pliers, knives, and hacksaws. Duties vary by setting. Preventive maintenance is a major responsibility of electronics repairers. Workers use power tools, testing equipment, and oscilloscopes. The purpose of the program is to prepare students for service, repair, and assembly of electrically and electronically driven or controlled devices. The program theory and application includes mechanical assemblies, electrical circuitry, and electronic principles including basic digital circuitry.

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GENERAL OBJECTIVES

Grade 10

The student will:

1. Demonstrate good safety practices at all times.
2. Demonstrate basic skills with the common hand and power tools of the trade.
3. Install and explain simple series, parallel and series - parallel circuits.
4. Demonstrate proper use of basic test equipment and explain fundamental principles involved.
5. Do the basic machine work applicable to the electrical trade.
6. Calculate and wire a typical residential installation.

Grade 11

1. Install and explain common appliances and/or their components.
2. Install all types of raceways and wireways.
3. Install and explain single phase motors and basic controllers.
4. Install and explain three phase motors and basic controllers.
5. Install and explain basic D.C. generators, motors, and controls.

Grade 12

1. Install D.C. controllers.
2. Install A.C. controllers.
3. Analyze, explain and install simple electronic circuits and components.
4. Wire transformer connections.
5. Install poly phase controllers/machines.
6. Calculate and wire a small apartment and small single purpose factory.

CURRICULUM BY MAJOR AREA

I. Shop Orientation and Tour
II. Electrical Trade Introduction
III. Shop/Trade Safety
IV. Matter and Electric Theory
V. Current Electricity
VI. Fundamentals of D.C. and A.C. Electricity
VII. Measuring and Calculating Resistance
VIII. Three Wires Circuits
IX. Residential Electrical Wiring
X. Line Drop and Measuring Power
XI. Magnetism
XII. Meter Types
XIII. Use of Meters
XIV. Electro-Magnetic Induction and E.M.F. Generation
XV. Estimating
XVI. Multi-Family Dwellings
XVII. Circuit Protection
XVIII. Illumination
XIX. Alternating Current
XX. Industrial Application of Electro-Magnets
XXI. Electrical Instruments - Review
XXII. D.C. Generators
XXIII. D.C. Motors
XXIV. Transformer Principles
XXV. A.C. Single Phase Motors
XXVI. A.C. Three Phase Motors
XXVII. A.C. Motors Control
XXVIII. Commercial Locations
XXIX. D.C. Motor Controls
XXX. A.C. Across the Line Controls
XXXI. Basic Electronics
XXXII. A.C. Controls Reduced Voltage
XXXIII. Pilot Devices
XXXIV. Programmable Controller Applications
XXXV. Transformers
XXXVI. Polyphase Currents
XXXVII. Industrial Locations
XXXVIII. Hazardous Locations
XXXIX. Preventive Maintenance
XXXX. Customer Relations and Business Practices
XXXXI. N.E.C., O.S.H.A., and B.O.C.A.

COMPETENCIES

I. Shop Orientation and Tour

A. Tour Shop for Safety
B. Wear Safety Equipment
C. Install with Screwdriver
D. Install with Plier
E. Install with Knife/Stripper
F. Install with Hammer
G. Install with Wrench
H. Install with Awl
I. Cut with Hand Saw
J. Cut with Hack Saw
K. Cut with Key Hole Saw
L. Use Proper Breathing Protection
M. Use Wood Chisel
N. Use Cold Chisel
O. Use Masonry Chisel
P. Remove Nails

II. Basic Safety with Electricity

A. Check Voltage with Meter
B. Observe Safety Rules
C. Apply Power in Shop
D. Use Shop Power Supplies
E. Insure Proper Grounding
F. Use Ground Fault Interrupter
G. Use Proper Cords

III. Wires-Splices and Installation

A. Remove Insulation
B. Splice - three types
C. Tin, Iron and Wire
D. Connect to Screws
E. Solder Connections and Splices
F. Tape Splices
G. Splice Solderless Connectors
H. Make Extension Cord
I. Rewire Lamp

IV. Signal and Communication Wiring

A. Mount Pushbuttons
B. Mount Bells, Buzzers
C. Wire Bell and Pushbutton
D. Series/Parallel Buttons
E. Series/Parallel Bells
F. Wire to Cell-Transformers
G. Wire Return Call System
H. Wire Annunciators
I. Wire Signal Replay
J. Wire Burglar/Fire Alarms
K. Wire Door Chimes
L. Wire Door Opener
M. Wire Communication Systems

V. Screws and Fasteners Insulation

A. Drill in Wood/Masonry
B. Toggle/Moly Bolts
C. Wood/Sheet Metal Screws
D. Machine Screws/Bolts
E. Common/Finish Nails
F. With Adhesives
G. Expansion Shield

VI. Basic Power Tool Use

A. Drill with Power Drills
B. Use Hole Saws
C. Cut with Sawsall
D. Cut with Saber Saw
E. Cut with Power Saw
F. Drill/Hammer Rotary
G. Drill Masonry

VII. Matter and Electricity

A. EMF by Pressure
B. EMF by Heat
C. EMF by Light
D. EMF by Chemical
E. EMF by Magnetic

VIII. Current Electricity

A. Demonstrate Earth as Conductor
B. Gases as Conductor
C. Vacuum as Conductor
D. Liquids as Conductor
E. Direction of Flow
F. Potential Difference
G. Varying Rate of Flow
H. Test Conductor/Non-Conductor
I. Test for Short Circuit
J. Test Grounded Circuit

IX. Basic Machine Work

A. Drill Holes
B. Grind Drills
C. Layout and Center Punch
D. Counterbore
E. Ream
F. File (rough)
G. File (finish)
H. Chip and Cut with Chisel
I. Use Protable Drill
J. Apply Cutting Oil
K. Use Hand Adjustable Dies
L. Sharpen Drill Bits
M. Rough Drill in a Vise
N. Hand Tap and Ream
O. Use Micrometer
P. Dress a Screwdriver
Q. Sharpen Hand Tools

X. Fundamentals of Electricity A.C./D.C.

A. Test Heat Conductor Size
B. Test Heat Conductor Material
C. Test Heat Time Interval
D. Test Heat Current Amount
E. Test Heat Conductor Length
F. Read Volts Series Circ.
G. Read Amps Series Circ.
H. Read OHMS Series Circ.
I. Read Volts Parallel Circ.
J. Read Amps Parallel Circ.
K. Read OHMS Parallel Circ.
L. Test Series Parallel Dry Cell
M. Test/Calculate Power

XI. Climbing/Rigging Work

- A. Climb on Step Ladder
- B. Raise/Climb Extension Ladder
- C. Assemble/Climb Scaffolding
- D. Wear Safety Harness
- E. Raise, Lower Equipment/Ladders
- F. Raise, Lower Equipment/Scaffolding
- G. Rigging

XII. Measure/Calculate Wire Resistance

- A. Test RI KL/D2
- B. Test R Wire Length
- C. Measure Ohmmeter
- D. Measure Meggar
- E. Measure Wheatstone Bridge

XIII. Three Wire System

- A. Measure E and I Balanced
- B. Measure E and I Unbalanced
- C. Check Power Volt-Amp
- D. Check Neutral Load
- E. Check Open Neutral

XIV. Line Drop Measure Power

- A. Check Heat on Wire
- B. Calculate Power Loss
- C. Measure Power
- D. Check Voltage Drop
- E. Check Voltage Drop No Load
- F. Check Voltage Drop Loaded

XV. Open Wiring - Installation

- A. Receptacles/Switches
- B. Surface Type Switches
- C. Single Pole/3-Way Switches
- D. Open Wiring Circuits
- E. Open Wiring to B.X.

XVI. Non-Metallic Wire and Boxes

- A. Identify Types and Sizes
- B. Strip and Skin Cable
- C. Install Connectors and Clamps
- D. Use Boring Tools
- E. Calculate Box Sizes
- F. Install Old Work Boxes
- G. Install Fittings/Devices
- H. Ground According to N.E.C.
- I. Check Installation

XVII. Magnetism

A. Check Magnetic/Nonmagnetic
B. Check Magnets
C. Show Magnetic Field Bar
D. Magnetize Materials
E. Check Magnetic Induction
F. Screen Magnetism
G. Test Magnetic Field Conductor
H. Test Residual Magnetism
I. Test Electro Magnet
J. Check Electro Magnet Polarity
K. Check Electro Magnet Strength

XVIII. Metal Clad Cable

A. Select Types and Sizes
B. Handle Coils
C. Cut Cable
D. Install Connectors and Clamps
E. Install Anti-short Bushings
F. Calculate Box Size
G. Install Old Work Boxes
H. Install Boxes/Supports
I. Install Switches, Lights/Receptacles
J. Install 3-ways/Pilot Light
I. Install 3-ways/4-ways

XIX. Use of Special Meter/Tester

A. Check Use V.O.M.
B. Check with Wattmeter
C. Check Clamp on Ammeter
D. Check with Oscilloscope
E. Check Frequency
F. Use Circuit Tracer
G. Use GFI Tester
H. Use Megger
I. Use Ground Tester
J. Test with Capacitance
K. Test with Inductance

XX. Troubleshooting/Meters Check

A. Feeders
B. Fuses/Record Results
C. Opens
D. Shorts
E. Grounds
F. Relays, Switches, Controls
G. Motors, Transformers, Coils
H. Armatures, Capacitors
I. Starting Switches

J. Florescent Lamps
K. Various Types Lamps
L. Ballasts
M. Lighting Fixtures
N. Switching
O. Rating of Circuits

XXI. Residential Wiring Installation

A. Install Cable Systems
B. Install/Caculate Boxes
C. Install/Trim Fixtures
D. Install 3-ways/4-ways
E. Install Switch with Pilot
F. Install Low Voltage
G. Install Ground Fault Interrupter
H. Install Telephone System
I. Install Fire/Smoke System
J. Install Security System
K. Install Closed Loop Programmed System
L. Install Swimming Pool/Spa

XXII. Residential Appliances Installation

A. Install Electric Heat
B. Install Gas Heat
C. Install Oil Heat
D. Install H.V.A.C.
E. Install Water Heater
F. Install Air Conditioner
G. Install Ranges/Ovens
H. Install Washers/Dryers
I. Install Dishwasher
J. Install Microwave
K. Install Photo Electric
L. Install Infrared
M. Install Timers
N. Install Solar Systems
O. Install Heat Pumps

XXIII. E.M.T. Conduit

A. Calculate Size
B. Cut and Ream
C. Install Fittings/Boxes
D. Install Inside/Outside Types
E. Hand Bend - 90o/Offset
F. Power Bend - 90o/Offset
G. Connect to Flexible Conduit
H. Adapt to Metal Moulding
I. Install Supports/Clamps

XXIV. Rigid/IMC Conduit

A. Calculate Size
B. Install Conduit
C. Hand Bend - 90o/Offset
D. Power Bend - 90o/Offset
E. Thread Hand
F. Thread Power
G. KO Punches/Hand/Power
H. Pull Wire, Hand
I. Pull Wire, Power
J. Connect Flexible Conduit
K. Install Sealtight
L. Install Hangers/Racks
M. Install Channel/Angle Iron
N. Install Locknuts/Bushings
O. Install Boxes/Fittings
P. Install Hazardous Areas
Q. Install Damp Areas
R. Install Through Fire-Rated Walls
S. Install Through Fire-Rated Floors

XXV. P.V.C. Conduit

A. Calculate P.V.C. Size
B. Cut P.V.C.
C. Ream P.V.C.
D. Bend P.V.C.
E. Fish Wires in P.V.C.

XXVI. Residential Services

A. Overhead
B. Underground
C. Service Cable
D. Service Conduit
E. Outside/Inside Meters
F. Single/Multiple Meters
G. Panel Boards/Switch Gear
H. Ground for Service
I. In Accordance with Codes
J. 1 0 and 3 0 Service

XXVII. Raceways and Wireways

A. Cut/Ream
B. Install Fittings/Boxes
C. Mount and Fasten
D. Bend Offset
E. Ground
F. Install Overhead Bus
G. Install Overhead Wireways
H. Install Under Floor Bus
I. Install Bus Drops and Switches
J. Install Prefab Harness
K. Install Pole Drops

XXVIII. Multifamily Dwelling

A. Calculate Load
B. Install Services
C. Install Lighting
D. Install Outlets
E. Install Various Wiring Methods
F. Wire Appliances
G. Wire Special Circuits
H. Wire Low Voltage

XXIX. Illumination

A. Install Incandescent
B. Install Florescent
C. Install Metal Halide
D. Install Mercury Vapor
E. Install Sodium Pressure
F. Install Neon
G. Calculate Light Levels
H. Install Light Control

XXX. Alternating Current Principles

A. Check Capacitor
B. Check Capacitor A.C. Response
C. Check Capacitor D.C. Response
D. Show Capacitor Phase Angle
E. Wire R.C. Circuit
F. Check Inductor
G. Check Inductor A.C. Response
H. Check Inductor D.C.
I. Check Inductor Phase
J. Wire RL Circuit
K. Check RLC Circuit

XXXI. Generator Characteristics

A. Graph Resistance of Armature
B. Graph Resistance of Series Field
C. Graph Resistance of Shunt Field
D. Graph Series Generator
E. Graph Characteristic Curve
F. Graph Shunt Generator
G. Graph Characteristic Curve
H. Graph Compound Generator (cumulative)
I. Curve (flat)
J. Curve (over)
K. Curve (under)
L. Curve (differential)
M. Two Parallel Shunt Generators
N. Two Parallel Compound Generators

XXXII. D.C. Motor Characteristics and Regulation

   A. Wire Speed Control - Series Motor
   B. Wire Speed Control - Shuntmotor
   C. Connect Compound Motor
   D. Graph Characteristic Curve
   E. Connect Compound Motor
   F. Graph Curve
   G. Connect Series Motor
   H. Graph Curve
   I. Wire Ward-Leonard Type System

XXXIII. Transformer Principles (Basic)

   A. Mutual Induction
   B. Test Primary vs. Secondary
   C. Check Current Transformer
   D. Check Potential Transformer

XXXIV. Single Phase Motors

   A. Induction Motor
   B. Squirrel Cage Induction Motor
   C. Squirrel Cage Split
   D. Synchronous Motor
   E. Clutch Type
   F. Capacitive Motor
   G. Induction Motor (Shaded Pole)
   H. Series Motor (Universal Types)
   I. Repulsion Motor
   J. Repulsion Start-Induction Run

XXXV. A.C. Three-Phase Motor

   A. Connect 9 Lead Dual Voltage Motor
   B. Connect 3 0 Alternator
   C. Connect Measure Coil Voltage
   D. Connect 3 0 Alternator to Load
   E. Synchronize Two 3 0 Alternator
   F. 3 0 Alternator as 3 0 Motor
   G. 3 0 Motor for P.F. Correction
   H. Connect Synchronous
   I. Connect Wound Rotor

XXXVI. A.C. Motor Control Basics

   A. Switches
   B. Manual Starters
   C. Magnetic/Across the Line
   D. Simple Control Circuits
   E. Interlock Relay
   F. Timing/Latching Relays
   G. Drum Switches
   H. Forward and Reverse
   I. Drum Switches 2-Speed

XXXVII. Commercial Building Installation

- A. Interpret Commercial Prints
- B. Install Various Wire Methods
- C. Install Commercial Service
- D. Install Commercial Low Voltage
- E. Install Branch Circuits
- F. Install H.V.A.C.
- G. Install Commercial Appliances
- H. Install Special Circuits
- I. Install Alarms/Security
- J. Install TV/Telephone

XXXVIII. D.C. Motor Control - Wire

- A. Full Voltage Starter
- B. 3 or 4 Point Starting Box
- C. D.P.D.T. for Rev. Shunt Wound
- D. Rev. Compound/Drum Switch
- E. Starter - 2 or 3 Step Acceleration
- F. Dynamic Braking Circuit
- G. Speed Control Combined Function - DB

XXXIX. D.C. Motor Problem

- A. Windings for Short
- B. Windings for Opens
- C. Windings for Grounds
- D. Bearings
- E. With V.O.M. - Shorts/Megger

XXXX. A.C. Motor Control - Wire

- A. Manual 3-Pole Starter
- B. Magnetic 3-Pole Starter
- C. Motor/Pilot Control
- D. Start and Stop Station
- E. Low Voltage Control
- F. Start, Jog, Stop
- G. Using Selector Switch
- H. Start, Double Jog, Stop
- I. Forward/Reverse Mag (no interlock)
- J. Forward/Reverse Drum Switch
- K. Forward/Reverse Mag. (Electric Interlock)
- L. Forward/Reverse Mag. (2 Limit Switch)
- M. Double Forward and Reverse Station

XXXXI. Electronic Circuits

- A. Vacuum Tube Diode
- B. Vacuum Tube Triode
- C. Multi Element Tube
- D. Gas Filled Tube

E. Semi Conductor Diode
F. Junction Diode
G. LED
H. Zener Diode
I. Halfwave Rectifier
J. Filter Circuit
K. Voltage Regulation
L. Transistor Types
M. SCR Circuit
N. Traic Circuit
O. And/Or Circuit
P. Nand/Nor Circuit
Q. Flip Flop
R. Time Delay
S. Integrated Circuit
T. Microprocessor

XXXXII. Reduced Voltage Starters

A. Reduced Voltage Hand
B. Reduced Voltage Automatic
C. Autotrans. Starter-Manual
D. Autotrans. Starter-Auto
E. Part Winding Starter
F. Wye-Delta Starter
G. 3 O Wound-Rotor Motor

XXXXIII. Pilot Devices

A. Wire Push Buttons
B. Wire Solid State Relay
C. Wire Solid State Contactor
D. Wire Timing Relays/Devices
E. Wire Float Switch
F. Wire Flow Switch
G. Wire Limit Switch
H. Wire Pressure Switch
I. Wire Temperature Sensor
J. Wire Proximity
K. Wire Hall Effect
L. Wire Photo Switches
M. Wire Fiber Optic

XXXXV. Solid State 1 Programmable Controls

A. Wire Solid State Relay
B. Wire Basic Logic Circuits
C. Connect Solid State A.C. Starter
D. Connect Solid State D.C. Starter
E. Set up Programmable Controller
F. Wire Input to P.C.
G. Wire Output to P.C.
H. Program Timers

I. Program Counters
J. Connect Basic Process Control
K. Wire Variable Frequency Control
L. Wire Soft Start Control
M. Wire Electronic Brake

XXXXVI. Transformers Wire

A. Single Phase Transformer
B. Check Polarity
C. In Parallel
D. In Series
E. Edison System
F. Check Shorts
G. Check Core Loss
H. Wire Two Phase System
I. Wire Scott 5 Wire
J. Wire Delta to Delta
K. Wire T to T
L. Wire Wye to Wye
M. Delta to Wye
N. Wye to Delta
O. Wire Voltage Transformer
P. Wire Current Transformer
Q. Wire Potential Transformer
R. Wire Variable Auto Transformer
S. Wire Magnetic Amplifier

XXXXVII. Poly Phase Currents

A. Connect Three Phase Alternator
B. Wire Alternator Delta
C. Wire Altnerator Wye
D. Synchronize Two Alternators
E. Operate Alternator as Motor
F. Operate Synchronous Motor

XXXXVIII. Industrial Locations - Wire

A. Wire Industrial Services
B. Wire Feeder Distribution
C. Wire Signal Systems
D. Wire for Motor Control
E. Wire H.V.A.C.
F. Wire Special Systems
G. Wire Signal
H. Wire Cranes/Hoists

XXXXIX. Hazardous Locations

A. Identify Classes
B. Install for Division/Group
C. Wire Special Occupancies
D. Select Approved Equipment

XXXXX. Preventive Maintenance

- A. Perform Residential Checks
- B. Commercial Heat System
- C. Commercial Lights
- D. Commercial Electro-Mech
- E. Commercial Ventilation
- F. Commercial Powe System
- G. Industrial H.V.A.C.
- H. Industrial Machines
- I. Industrial Controls
- J. Industrial Power System

XXXXXI. Oxyacetylene Welding

- A. Assemble Oxyacetylene Comp.
- B. Prepare Oxyacetylene Unit
- C. Connect Proper Tips
- D. Run a Bead
- E. Make Tack/Butt Weld
- F. Make Corner Weld
- G. Run Bead with Bronze
- H. Use Comparison Guide
- I. Make Straight/Level Cuts
- J. Cut Holes
- K. Welding/Chemical

XXXXXII. Electric Welding

- A. Connect/Set Welder
- B. Identify Metals/Select Rod
- C. Strike an Arc
- D. Tack/Butt Weld
- E. Weld Flat Beads
- F. Weld Bat/Fillet Joints
- G. Weld Corner Joints

CURRICULUM

I. SHOP ORIENTATION AND TOUR

A. Shop Rules
   1. Hazardous areas in shop
   2. Student responsibility
   3. Daily shop procedures

II. ELECTRICAL TRADE INTRODUCTION

A. State of Connecticut Apprenticeship Program
   1. Construction electrician
   2. Maintenance/industrial electrician

B. Employment Opportunities
   1. Normal trade entry
   2. Other electrical related professions
   3. Anticipated changes in the trade

III. SHOP/TRADE SAFETY

(Note: Advanced and Speciality tools/safety to be studied as applied later in the course.)

A. Personal Safety Equipment
   1. Glasses, shoes, hard hat, uniform
   2. Breathing protection where applicable

B. Hand Tools and Their Use
   1. Basic trade hand tools

C. Standard Trade Power Tools
   1. Drilling tools
   2. Cutting tools
   3. Fastening tools

D. Ladders

E. Safety with Electricity
   1. Rule on applying power
   2. How to check/use voltage
   3. Basic shop power supplies

IV. MATTER AND ELECTRIC THEORY

A. Electrostatic Introduction

B. Electrostatic Charges

C. E.M.F.
   1. E.M.F. by pressure
   2. E.M.F. by heat
   3. E.M.F. by light
   4. E.M.F. by chemical action
   5. E.M.F. by magnetic action

V. CURRENT ELECTRICITY

- A. Direction of Flow of Electricity
- B. Potential Difference and Pressure
- C. Potential Difference, Varying Rate of Flow
- D. Conductors and Non-Conductors
  - 1. Earth as a conductor
  - 2. Gases as conductors
  - 3. Vacuum as conductor
  - 4. Liquids as conductors
- E. Short Circuits
- F. Grounding Electrical Systems

VI. FUNDAMENTALS OF D.C. AND A.C. ELECTRICITY

- A. Elementary A/C and D/C Comparison
  - 1. D/C voltage - current output
  - 2. A/C sine wave introduction
    - a. Effective value
- B. Thermo Electric Principle
- C. Heating Effect in Conductors A/C and D/C
  - 1. Heating effect in different size conductors
  - 2. Heating effect in conductors of different materials
  - 3. Heating effect with different time intervals
  - 4. Heating effect using different amount of current
  - 5. Effect of temperature on different conductor length
  - 6. Effect of temperature on resistance
  - 7. Effect of pressure on resistance and on commercial application of heat
- D. Series Circuits Principles A/C and D/C
  - 1. Connecting and reading a voltmeter
  - 2. Connecting and reading an ammeter
  - 3. Connecting and reading an ohmmeter
  - 4. Voltage in a series circuit
  - 5. Current in a series circuit
  - 6. Resistance in a series circuit
- E. Parallel Circuit Principles A/C and D/C
  - 1. Voltage parallel circuit
  - 2. Current parallel circuit
  - 3. Resistance parallel circuit
- F. Ohm's Law Basic A/C and D/C
  - 1. Ohms Law I=E/R
  - 2. Ohms Law E=IxR
  - 3. Ohms Law R=E/I
  - 4. Ohms Law applied to a part of a circuit
- G. Resistance Voltmeter-Ammeter Method
- H. Cell Connections
  - 1. Cells connected in series and parallel
  - 2. Cells resistance and current capacity
  - 3. Cells E I and R in series-parallel
- I. Electrical Work and Power

VII. MEASURING AND CALCULATING RESISTANCE

A. Resistance of Materials
  1. Resistance-length
  2. Resistance-cross section
  3. Resistance-shape
  4. Resistance calculated by R = KL/D2
  5. Use of wire table
  6. Resistance measurements
  7. Ohmmeter
  8. Megger
  9. Wheatstone bridge

VIII. THREE WIRE CIRCUITS

A. Three Wire System
  1. Balanced and unbalanced load
  2. Effect on open neutral
  3. Calculations of 3-wire circuits

IX. RESIDENTIAL ELECTRICAL WIRING
(One and Two Family)

A. Blue Print Reading
  1. Symbols - abbreviations
  2. Circuit calculations
  3. Introduction to code
B. Outlet Boxes
  1. Types and installation
  2. Conductor fill
C. Wiring Methods and Installation
  1. Knob and tube (old work)
  2. Romex (non-metallic sheathed cable)
  3. Armored cable
  4. Tubing, non-metallic tubing
  5. Special and low voltage installation
    a. Television, telephone, signal systems
    b. Fire/smoke systems
    c. Security systems
    d. Closed loop/programmed power
    e. Intercom systems
  6. Code application NEC
    a. Basements
    b. Through members
    c. Attics
D. Branch Circuit Installations
  1. General lighting and outlets
    a. Living areas
    b. Basements
    c. Attics
  2. Switching arrangements

- E. Services
    1. Calculations
    2. Installation types
    3. Grounding
    4. Installation-code application
- F. Equipment Installation
    1. Fixed/small appliance installation
    2. Heating system installations
        - a. oil, gas, electric
    3. Air conditioning installation
- G. NATIONAL ELECTRICAL CODE RESIDENTIAL
    1. General
    2. BOCA requirements
- H. Ground Fault Protection
    1. Construction site
    2. Kitchen, basement, outdoor, bathroom, garage
    3. Swimming pools

X. LINE DROP AND MEASURING POWER

- A. Line Drop
    1. Calculating size of wire
    2. Power loss through heat
    3. Measuring power

XI. MAGNETISM

- A. Principles of Magnetism
    1. Magnetic and non-magnetic substances
    2. Magnetization
    3. Magnets
    4. Magnetic fields of bar magnets
    5. Magnets and poles
    6. Magnetic fields
    7. Mutual action of two magnets
    8. Making a permanent magnet
    9. Breaking magnets
    10. Magnetic induction
    11. Magnetic screens
    12. Magnetic field around a conductor
    13. Magnetic effect produced by current
    14. Permanent magnets
    15. Residual magnetism
    16. Electro-magnets-magnetic effect and strength
    17. Polarity of an electro-magnet
    18. Electric bell-relay
    19. Electric door opener
    20. Annunicators

XII. METER TYPES

- A. Meter Construction and Principles
    - 1. D'Arsonval movement
    - 2. D.C. ammeters (D'Arsonval)
    - 3. D.C. voltmeter (D'Arsonval)
    - 4. Dynamometer movement
    - 5. Electro-Dynamometer movement
    - 6. Wattmeter
    - 7. Iron Vane movement-principle
    - 8. Iron Vane movement-construction

XIII. USE OF METERS

- A. Ohm Meter
    - 1. In a series circuit
    - 2. In a parallel circuit
- B. Voltmeter and Voltmeters with Multiplier
    - 1. In a series circuit
    - 2. In a parallel circuit
- C. Ammeter and Ammeters with External Shunt
    - 1. In a series circuit
    - 2. In a parallel circuit
- D. Voltage Tester
    - 1. In a series circuit
    - 2. In a parallel circuit
- E. V.O.M. Meters
    - 1. In a series circuit
    - 2. In a parallel circuit
- F. Millivoltmeters
    - 1. In a series circuit
    - 2. In a parallel circuit
- G. Wattmeter
    - 1. In a series circuit
    - 2. In a parallel circuit
- H. Clamp-on Ammeter

XIV. ELECTRO-MAGNETIC INDUCTION AND E.M.F. GENERATION

- A. Electro-magnetic Induction
- B. Lenz's Law
- C. Magneto
- D. A Simple Generator
- E. Alternator

XV. ESTIMATING

- A. Electrical Wiring Specifications
- B. Single Family House
- C. Multi Family Dwelling
- D. Commercial Building

XVI. MULTI-FAMILY DWELLINGS

- A. Load Calculations
- B. Services and Feeders
- C. Wiring and Methods of Wiring
  - 1. General lighting and outlets
  - 2. Types of installation
- D. H.V.A.C.
- E. Appliances
- F. Special Circuits

XVII. CIRCUIT PROTECTION

- A. Fuses
- B. Thermal Breakers
- C. Magnetic Breakers
- D. Oil Breakers
- E. Air Blast Type

XVIII. ILLUMINATION

- A. Incandescent
- B. Florescent
- C. Metal Vapor
- D. Sodium Pressure
- E. Neon
- F. Quality Requirements of Lighting
- G. Interior Lighting Design
- H. Lighting Design
- I. Home Lighting

XIX. ALTERNATING CURRENT

- A. Alternating Current Principles
  - 1. A.C. sine curve
  - 2. Other wave forms
  - 3. A.C. characteristics and values
  - 4. A.C. magnetic field
  - 5. A.C. circuit (resistance only)
- B. Inductance
  - 1. A.C. circuit (resistance and inductance in series)
  - 2. Action of the capacitor
- C. Capacitance
  - 1. Electroytic and dry-capacitors
  - 2. A.C. circuit (resistance and capacitance in series)
  - 3. A.C. circuit (resistance-capacitance-inductance in series)
  - 4. Resistance-inductance-capacitance to find impedance.
- D. Impedance
  - 1. Capacitors in parallel
  - 2. Inductors in parallel
- E. Effects Produced by A.C.

XX. INDUSTRIAL APPLICATION OF ELECTRO-MAGNETS

A. Tractive Electro-Magnets
B. Portative Electro-Magnets
C. Relays
D. Magnetic Contactors

XXI. ELECTRICAL INSTRUMENTS-REVIEW

A. D'Arsonval Movement
B. D.C. Ammeters
C. D.C. Voltmeters
D. Dynamometers
E. Electro-Dynamometers
F. Wattmeter
G. Iron Vane Meters
H. Megger
I. Clamp-on Ammeter-Voltmeter
J. Digital Multi-meter
K. Oscilloscope

XXII. D.C GENERATORS

A. D.C. Generator
B. D.C. Generator (commutating poles)
C. E.M.F. of Self Induction
D. Effect of Commutation and Self Induction
E. D.C. Generator (various types)
F. Amplidyne
G. D.C. Generators - Losses - Efficiencies
H. Pre-test and Inspection of Generator
I. Parallel operation - Shunt and Compound

XXIII. D.C. MOTORS

A. Motor Action
B. Motor Principles
C. Counter Electromotive Force
D. Starting and Stopping
E. 3 and 4 Point Starting Boxes
F. Reversing Shunt Motor
G. Starting and Reversing - Compound Motor
H. Starting and Reversing - Series Motor
I. D.C. Speed Control
J. D.C. Drum Switch
K. Dynamic Braking
L. Automatic D.C. Starters
M. Locating Troubles in D.C. Starters
N. Prony Brake
O. D.C. Shunt Motor Load Characteristics
P. D.C. Compound Motor Load Characteristics
Q. D.C. Series Motor Load Characteristics
R. Proper Selection of Motors (given job)

XXIV. TRANSFORMER PRINCIPLES

A. Current
B. Potential

XXV. A.C. SINGLE PHASE MOTORS

A. Induction Motor
B. Squirrel Cage Induction Motor
C. Squirrel Cage Induction Motor (Split phase)
D. Clutch Type
E. Capacitive Start Motor
F. Induction Motor (Shaded Pole)
G. A.C. Series Motor (Universal)
H. Repulsion Action
I. Repulsion Motor
J. Repulsion Start - Induction Motor
K. Reversing Switches and Controllers
L. Testing A.C. Motors
M. Grounding Machines and Apparatus
N. Maintaining and Inspection - Elec. Machines

XXVI. A.C. THREE PHASE MOTORS

A. Squirrel Cage
    1. Dual voltage
B. Wound Rotor
C. Synchronous

XXVII. A.C. MOTOR CONTROL

A. A.C. Magnetic Motor Starters
B. Speed Control of A.C. Motors
C. Remote Start-Stop
D. Remote Control - Start-Stop-Reverse
E. Control - Pilot Devices
F. Solenoid Valves - Air-Oil-Water
G. Circuit Layout and Symbols

XXVIII. COMMERCIAL LOCATIONS

A. Commercial Building Plans
B. Commercial, Methods of Installation
C. Services, and Emergency Power
D. Low Voltage Systems
E. Branch Circuit Installation
F. H.V.A.C.
G. Commercial Appliances
H. Special Circuits
I. Alarm Systems

XXIX. D.C. MOTOR CONTROLS

A. Connect Magnetic Full Voltage Starter
B. Wire 3-Point Starting Box
C. Wire 4-Point Starting Box
D. Wire 4-Point Starting Box with Speed Control
E. Wire DPDT Switch for Reversing
F. Wire 4-Step Starter
G. Wire Dynamic Braking Circuit
H. Wire 4-Step Starter with Reversing and Breaking

XXX. A.C ACROSS THE LINE CONTROLS

A. Two Stations - Electrointerlock Start-Stop Stations
B. Magnetic Starter to Low Voltage One Station Start-Stop Control
C. Start-Jog-Stop Motor Starter
D. Jog-Stop Station Using Jog Relay
E. 2 Station Jog-Stop Motor Starter
F. Starter Arrangement for Sequence Control of Conveyor System-Two Motors
G. 1 Station Forward-Reverse-Stop Control
H. 3 Station Forward-Reverse-Stop Control
I. 1 Station Forward-Reverse-Stop Using 2 Crt. Buttons to Provide Electrical Interlock
J. 2 Station Forward-Reverse-Stop with 2 Switches to Provide Interlocks with Forward-Reverse Indicating Light
K. Three Phase Motor to Provide Plugging From One Direction with Lock-Out Relay

XXXI. BASIC ELECTRONICS

A. Semiconductor Devices
   1. P/N junction
   2. Zener diode
   3. Transistor
   4. Uni junction transistor
   5. SCR
   6. Light emitting diode
   7. Diac/triac
B. Power Supplies
   1. Rectifiers
C. Timers
D. Light Sensitive Devices

XXXII. A.C. CONTROLS REDUCED VOLTAGE

A. Part Winding Starting
B. Y-Delta Starting
C. Auto Transformer Starter
   1. Manual
   2. Automatic
D. Reduced Voltage Starter - Resistance Type
E. Dynamic Brake Control

F. Three Phase Wound Rotor Motor Face Plate Type Control
G. Three Phase Wound Rotor Drum Control
H. Three Phase Wound Rotor Control (Automatic)
I. Full Voltage Synchronous Motor Starter
J. Frequency Changer
K. Induction Regulator
L. Synchronous Rotary Converter

XXXIII. PILOT DEVICES

A. Push Buttons
B. Relay and Contactors
C. Timing Relays/Devices
D. Switches
    1. Float/flow/limit/pressure/temp.
E. Detectors-Sensors
    1. proximity/hall effect/photo devices

XXXIV. PROGRAMMABLE CONTROLLER APPLICATIONS

A. Programmable Controllers
B. Input/Output
C. Programming
D. Timers/Counters
E. Process Control Applications
F. Soft Start/Variable Frequency Controllers
G. Electronic Brake

XXXV. TRANSFORMERS

A. Check Polarity of Transformer
B. Connect Transformers in Parallel
C. Connect Transformer for 3-Wire System
D. Connect Single Phase Transformers in Series
E. Short Circuit Test on Transformer
F. Core Test on Transformer
G. Connecting and Operating Current Transformers
H. Three Phase Connections
    1. Open delta to open delta (also 4-wire)
    2. Closed delta to closed delta (also 4-wire)
    3. Wye to wye
    4. Delta to wye (3 and 4-wire)
    5. Wye to delta
I. Grounding of Electrical Equipment-Apparatus
J. 2 Phase, 4 and 5-wire

XXXVI. POLYPHASE CURRENTS

A. Connect Three Phase Alternator
    1. Measure coil voltages
B. Wire Three Phase Alternator
    1. Wye
    2. Delta

C. Synchronize Two Three Phase Alternators
D. Operating Three Phase Alternator as a Three Phase Motor
E. Operating a Three Phase Synchronous Motor

XXXVII. INDUSTRIAL LOCATIONS

A. Industrial Services
B. Feeder Distribution
C. Signal Systems
D. Motor and Control Applications
E. H.V.A.C.
F. Special Circuits

XXXVIII. HAZARDOUS LOCATIONS

A. Classes of Hazardous Locations
B. Divisions/Groups
C. Listed Special Occupancies
D. Material Applications

XXXIX. PREVENTIVE MAINTENANCE

A. Residential P.M. Checks
B. Commercial P.M. Program
A. Residential P.M. Checks
C. Industrial P.M. Program

XXXX. CUSTOMER RELATIONS AND BUSINESS PRACTICES

A. Dress and Appearance-First Impressions
  1. Clothing
    a. Neat
    b. Clean
  2. Personal appearance
    a. Cleanliness
    b. Personal hygiene
    c. Manners
      1. Polite
      2. Tactful
B. Courtesy to the Customer
  1. Telephone communication
    a. Courteous
    b. Sincere
    c. Listen
    d. Never argue but stand on facts
    e. Misunderstanding produces ill will

- 2. Association in person
  - a. Call customer by name
  - b. Pronounce name correctly
  - c. Efficient service
  - d. Brief, thorough
  - e. Satisfy complaints
  - f. Enthusiasm about company
  - g. Enthusiasm about product
- C. Customer Psychology
  - 1. Get the customer's story
  - 2. Agreement precedes disagreement
  - 3. Knowledge of product
  - 4. Ignorance kills customer confidence
  - 5. Show initiative
- D. Business Practices
  - 1. Maintain good records
    - a. Customer files
    - b. Service calls
    - c. Time spent
    - d. Part used
    - e. Billings
    - f. Correspondence
    - g. Inventory
    - h. Service bulletins
    - i. Cost (all costs)
    - j. Taxes (all taxes)
    - k. Gross income
    - l. Net profit
- E. Ethics
  - 1. Workmanship
  - 2. Parts cost
  - 3. Labor cost
  - 4. Overhead cost
  - 5. Promptness
  - 6. Contractual and implied obligations
  - 7. Customer consideration

XXXXI. N.E.C., O.S.H.A., AND B.O.C.A.

- A. Current N.E.C.
  - 1. Must be presented throughout the three year program
- B. Applicable O.S.H.A. Regulations
- C. Applicable B.O.C.A. and other requirements
  - 1. Connecticut Basic Building Code
  - 2. Underwriters and authorities

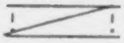
0083I

STUDENT PROGRESS RECORD

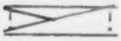
A major principle of vocational education is that students learn skills or the performance of operations of a trade with the production job as a vehicle to accomplish this objective.

The operations are defined on the shop progress record and it is imperative that the instructor have some means of recording the student experiences and achievement.

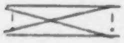
The approved method of recording student progress is as follows:



INSTRUCTED - This designation on the progress record indicates that the student has performed a skill with the assistance of and under the supervision of the instructor.



PRACTICED - This designation on the progress record indicates that the student has performed a skill with little help from the instructor.



PROFICIENT - This designation on the progress record indicates that the student is capable of performing a skill within a reasonable amount of time with no assistance from the instructor. In effect, this implies that the student has been tested for that skill.

This method of noting student progress will define accurately student achievement and, in fact, will point out any weaknesses the student may have in certain operations, thus highlighting areas where the student may need help.

Grades should be kept on student daily progress cards or in roll books.

Grade__________ Year__________ Instructor__________

STUDENT	TOOL CHECK NO.	LOCKER NO.	TEXT BOOK NO.	SHOP GRADES MARKING PERIOD						THEORY GRADES MARKING PERIOD					
				1	2	3	4		F	1	2	3	4		F

Grade........................Year.....Instructor..................

Locker No	Textbook No.	Shop Grades Marking Period						Theory Grades Marking Period					
		1	2	3	4		F	1	2	3	4		F

Grade......................Year.....Instructor.................

Locker No	Textbook No.	Shop Grades Marking Period						Theory Grades Marking Period					
		1	2	3	4		F	1	2	3	4		F

Grade......................Year.....Instructor.................

Locker No	Textbook No.	Shop Grades Marking Period						Theory Grades Marking Period					
		1	2	3	4		F	1	2	3	4		F

Grade......................Year.....Instructor.................

Locker No	Textbook No.	Shop Grades Marking Period						Theory Grades Marking Period					
		1	2	3	4		F	1	2	3	4		F

Grade......................Year.....Instructor................

Locker No	Textbook No.	Shop Grades Marking Period						Theory Grades Marking Period					
		1	2	3	4		F	1	2	3	4		F

I. SHOP SAFETY HAND TOOL USE

Tour Shop For Safety	Wear Safety Equipment	Install with Screw Drivers	Install with Pliers	Install with Knife/Strippers	Install with Hammers	Install with Wrenches	Install with Awl	Cut with Hand Saw	Cut with Hack Saw	Cut with Key Hole Saw	Use Proper Breathing Protection	Use Wood Chisel	Use Cold Chisel	Use Masonry Chisel	Remove Nails

2. BASIC SAFETY WITH ELECTRICITY

Check Voltage with Meter	Observe Safety Rules	Apply Power in Shop	Use Shop Power Supplies	Insure Proper Grounding	Use Ground Fault Interrupter	Use Proper Cords									

3. WIRES-SPLICES AND INSULATION

Remove Insulation	Splice - 3 types	Tin Iron and Wire	Connect to Screws	Solder Connections & Splices	Tape Splices	Splice Solderless Connectors	Make Extension Cord	Rewire lamp							

4. SIGNAL AND COMMUNICATION WIRING

Mount Pushbuttons	Mount Bells, Buzzers	Wire Bell and Pushbutton	Series/Parallel Buttons	Series/Parallel Bells	Wire to Cell/Transformers	Wire Return Call System	Wire Annunciators	Wire Signal Replay	Wire Burglar/Fire Alarms	Wire Door Chimes	Wire Door Opener	Wire Communication Systems			

5. SCREWS & FASTENERS INSTALLATION

Drill in Wood/Masonry	Toggle/Moly Bolts	Wood/Sheet Metal Screws	Machine Screws/Bolts	Common/Finish Nails	With Adhesives	Expansion Shield									

6. BASIC POWER TOOL USE

Drill with Power Drills	Use Hole Saws	Cut with Sawsall	Cut with Saber Saw	Cut with Power Saw	Drill/Hammer Rotary	Drill Masonry									

7. MATTER AND ELECTRICITY

EMF By Pressure	EMF By Heat	EMF By Light	EMF By Chemical	EMF By Magnetic											

8. CURRENT ELECTRICITY

Demonstrate Earth As Conductor	Gases as Conductor	Vacuum as Conductor	Liquids as Conductor	Direction of Flow	Potential Difference.	Varying Rate of Flow	Test Conductor/Non-Cond.	Test for Short Circuit	Test Grounded Circuit						

9. BASIC MACHINE WORK

Drill Holes	Grind Drills	Layout and Center Punch	Counterbore	Ream	File (rough)	File (finish)	Chip and cut with chisel	Use portable drill	Apply cutting oil	Use hand adjustable dies	Sharpen drill bits	Rough drill in a vise	Hand tap and ream	Use micrometer	Dress a screw driver

BASIC MACHINE WORK (Continued)

Sharpen hand tools															

10. FUNDAMENTALS OF ELECTRICITY A.C./D.C.

Test Heat Conductor Size	" " Conductor Material	" " Time Interval	" " Current Amount	" " Conductor Length	Read Volts Series Circ.	Read Amps Series Circ.	Read OHMS Series Circ.	Read Volts Parallel Circ.	Read Amps Parallel Circ.	Read OHMS Parallel Circ.	Test Series Parallel Dry Cell	Test/Calculate Power			

11. CLIMBING/RIGGING WORK

Climb on step ladder	Raise/climb extension ladder	Assemble/climb scaffolding	Wear safety harness	Raise, lower equipment/ladders	Raise, lower equipment/scaffolding	Rigging									

12. MEASURE/CALCULATE WIRE RESISTANCE

Test RI KL/D2	Test R Wire Length	Measure Ohmmeter	Measure Meggar	Measure Wheatstone Bridge											

13. THREE WIRE SYSTEM

Measure E and I Balanced	Measure E and I un-Balanced	Check Power Volt-Amp	Check Neutral Load	Check Open Neutral											

14. LINE DROP MEASURE POWER

Check Heat on Wire	Calculate Power Loss	Measure Power	Check Voltage Drop	Check Voltage Drop No Load	Check Voltage Drop Loaded										

15. OPEN WIRING - INSTALLATION

Receptacles/switches	Surface Type Switches	Single pole/3-way switches	Open wiring circuits	Open wiring to B.X.											

16. NON-METALLIC WIRE AND BOXES

Identify types and sizes	Strip and skin cable	Install connectors and clamps	Use boring tools	Calculate box sizes	Install old work boxes	Install boxes/supports	Install fittings/devices	Ground according to N.E.C.	Check installation						

17. MAGNETISM

Check Magnetic/Non Magnetic	Check Magnets	Show Magnetic Field Bar	Magnetize Materials	Check Magnetic Induction	Screen Magnetism	Test Magnetic Field Conductor	Test Residual Magnetism	Test Electro Magnet	Check Electro Magnet Polarity	Check Electro Magnet Strength					

18. METAL CLAD CABLE

Select Types and Sizes	Handle coils	Cut cable	Install connectors and clamps	Install anti-short bushings	Calculate box size	Install old work boxes	Install boxes/supports	Install switches, lights/ receptacles	Install 3-ways/pilot light	Install 3-ways/4 ways					

19. USE OF SPECIAL METER/TESTER

Check Use V.O.M.	Check with Wattmeter	Check Clamp on Ammeter	Check with Oscilloscope	Check Frequency	Use Circuit Tracer	Use GFI Tester	Use Megger	Use Ground Tester	Test with Capacitance	Test with Inductance					

20. TROUBLE SHOOTING/METERS CHECK

Feeders	Fuses/record results	Opens	Shorts	Grounds	Relays, switches, controls	Motors, transformers, coils	Armatures, capacitors	Starting switches	Florescent lamps	Various types lamps	Ballasts	Lighting Fixtures	Switching	Rating of circuits	

21. RESIDENTIAL WIRING INSTALLATION

Install Cable Systems	Install/Calculate Boxes	Install/Trim Fixtures	Install 3-ways/4-ways	Install switch with pilot	Install Low Voltage	Install Ground Fault Interrupter	Install Telephone System	Install Fire/Smoke System	Install Security System	Install Closed Loop Programmed System	Install Swimming Pool/ Spas				

22. RESIDENTIAL APPLIANCES INSTALLATION

Install Electric Heat	Install Gas Heat	Install Oil Heat	Install H.V.A.C.	Install Water Heater	Install Air Conditioner	Install Ranges/Ovens	Install Washers/Dryers	Install Dishwasher	Install Microwave	Install Photo Electric	Install Infrared	Install Timers	Install Solar Systems	Install Heat Pumps	

23. E.M.T. CONDUIT

24. RIGID/IMC CONDUIT

Calculate sizes	Cut and ream	Install fittings/boxes	Install inside/outside types	Hand bend - 90^0/offset	Power bend - 90^0/offset	Connect to flexible conduit	Adapt to metal moulding	Install supports/clamps					Calculate size	Install conduit	Hand bend - 90^0/offset

24. RIGID/IMC CONDUIT (Continued)

Power bend 90°/offset	Thread hand	Thread power	KO punches/hand/power	Pull wire, hand	Pull wire, power	Connect flexible conduit	Install sealtight	Install hangers/racks	Install channel/angle iron	Install locknuts/bushings	Install boxes/fittings	Install hazardous areas	Install damp areas	Install thru fire rated walls	Install thru fire rated floors

25. P.V.C. CONDUIT

Calculate P.V.C. size	Cut P.V.C.	Ream P.V.C.	Bend P.V.C.	Fish wires in P.V.C.											

26. RESIDENTIAL SERVICES

Overhead	Underground	Service cable	Service conduit	Outside/inside meters	Single/multiple meters	Panel boards/switch gear	Ground for service	In accordance with codes	1 Ø and 3 Ø service						

27. RACEWAYS AND WIREWAYS

	Cut/ream	Install fittings/boxes	Mount and fasten	Bend offset	Ground	Install overhead bus	Install overhead wireways	Install under floor bus	Install bus drops and switches	Install prefab harness	Install pole drops					

28. MULTIFAMILY DWELLING

Calculate Load	Install Services	Install Lighting	Install Outlets	Install Various Wiring Methods	Wire H.V.A.C.	Wire Appliances	Wire Special Circuits	Wire Low Voltage							

29. ILLUMINATION

Install Incandescent	Install Florescent	Install Metal Halide	Install Mercury Vapor	Install Sodium Pressure	Install Neon	Calculate Light Levels	Install Light Control								

30. ALTERNATING CURRENT PRINCIPLES

Check Capacitor	Check Capacitor AC Response	Check Capacitor DC Response	Show Capacitor Phase Angle	Wire RC Circuit	Check Inductor	Check Inductor AC Response	Check Inductor D.C.	Check Inductor Phase	Wire RL Circuit	Wire RLC Circuit					

31. GENERATOR CHARACTERISTICS

Graph Resistance of Armature	Graph Resistance of Series Field	Graph Resistance of Shunt Field	Graph Series Generator	Graph Characteristic Curve	Graph Shunt Generator	Graph Characteristic Curve	Graph Compound Generator (cumulative)	Curve (flat)	Curve (over)	Curve (under)	Curve (differential)	2 Parallel Shunt Generators	2 Parallel Compound Generators		

32. D.C. MOTOR CHARACTERISTICS AND REGULATION

Wire Speed Control-Series Motor	Wire Speed Control--shuntmotor	Connect Compound Motor	Graph Characteristic Curve	Connect Compound Motor	Graph Curve	Connect Series Motor	Graph Curve	Wire Ward-Leonard Type System							

33. TRANSFORMER PRINCIPLES (BASIC)

Mutual Induction	Test Primary Vs Secondary	Check Current Transformer	Check Potential Transformer												

34. SINGLE PHASE MOTORS

Induction Motor	Squirrel Cage Induction Motor	Squirrel Cage Split Ø	Syncronous Motor	Clutch Type	Capacitive Motor	Ind. Motor (Shaded Pole)	Series Motor (Universal Types)	Repulsion Motor	Repulsion Start-Induction Run						

35. A.C. 3 PHASE MOTORS

Connect 9 lead dual voltage motor	Connect 3 Ø alternator	Connect measure coil voltage	Connect 3 Ø alternator to load	Syncronize two 3 Ø alt.	3 Ø alt. as 3 Ø motor	3 Ø motor for P.F. correction	Connect Synchronous	Connect Wound Rotor							

36. A.C. MOTOR CONTROL BASICS

Switches	Manual starters	Magnetic/across the line	Simple control circuits	Interlock relay	Timing/latching relays	Drum switches	Forward and reverse	Drum switches 2 -speed							

37. COMMERCIAL BUILDING INSTALLATION

Interpret Commercial Prints	Install Various Wire Methods	Install Commercial Service	Install Commercial Low Voltage	Install Branch Circuits	Install H.V.A.C.	Install Comm. Appliances	Install Special Circuits	Install Alarms/Security	Install TV/Telephone						

38. D.C. MOTOR CONTROL - WIRE

Full voltage starter	3 or 4 point starting box	D.P.D.T. for rev. shunt wound	Rev. compound/drum switch	Starter - 2 or 3 step acceleration	Dynamic braking circuit	Speed control combined function - DB									

39. D.C. MOTOR PROBLEM

Windings for shorts	Windings for opens	Windings for grounds	Bearings	With V.O.M. - shorts/megger											

40. A.C. MOTOR CONTROL-WIRE

Manual 3-pole starter	Magnetic 3-pole starter	Motor/pilot control	Start and stop station	Low voltage control	Start, jog, stop	Using selector switch	Start, double jog, stop	Forward/reverse mag. (no interlock)	Forward/reverse drum switch	Forward/reverse mag. (elect. interlock)	Forward/reverse mag. 2 limit switch	Double forward and reverse station			

41. ELECTRONIC CIRCUITS

Vacuum tube diode	Vacuum tube triode	Multi element tube	Gas filled tube	Semi conductor diode	Junction diode	LED	Zener diode	Halfwave rectifier	Filter circuit	Voltage regulation	Transistor types	SCR circuit	Traic circuit	And/or circuit	Nand/Nor circuit

41. ELECTRONIC CIRCUITS

Flip flop	Time delay	Integrated circuit	Microprocessor												

42. REDUCED VOLTAGE STARTERS

Reduced voltage hand	Reduced voltage automatic	Autotrans starter-manual	Autotrans. starter-auto.	Part winding starter	Wye-Delta starter	3 0 wound-rotor motor									

43. PILOT DEVICES

Wire push buttons	Wire solid state relay	Wire solid state contactor	Wire timing relays/devices	Wire float switch	Wire flow switch	Wire limit switch	Wire pressure switch	Wire temperature sensor	Wire proximity	Wire hall effect	Wire photo switches	Wire fiber optic			

44. AUTOMATIC CONTROL CIRCUITS

Connect pneumatic timer to motor	Connect with simple pilot control	2-motor-sequence	Time delay	Plugging circuit											

45. SOLID STATE 1 PROGRAMMABLE CONTROLS

Wire solid state relay	Wire basic logic circuits	Connect solid state A.C. Starter	Connect solid state D.C. Starter	Set up programmable controller	Wire input to P.C.	Wire output to P.C.	Program timers	Program counters	Connect basic process control	Wire variable freq. control	Wire soft start control	Wire electronic brake			

46. TRANSFORMERS WIRE

Single phase transformer	Check polarity	In parallel	In series	Edison system	Check shorts	Check core loss	Wire two phase system	Wire scott 5 wire	Wire delta to delta	Wire T to T	Wire wye to wye	Delta to wye	Wye to delta	Wire voltage trans.	Wire current trans.

46. TRANSFORMERS (Continued)

Wire potential trans.	Wire variable auto trans.	Wire magnetic amplifier													

47. POLY PHASE CURRENTS

48. INDUSTRIAL LOCATIONS - WIRE

Connect 3 phase alt.	Wire alternator delta	Wire alternator wye	Synchronize two alt.	Operate alt. as motor	Operate synchronous motor			Wire Industrial service	Wire feeder distribution	Wire signal systems	Wire for motor control	Wire H.V.A.C.	Wire special systems	Wire signal	Wire cranes/hoists

49. HAZARDOUS LOCATIONS 50. PREVENTIVE MAINTENANCE - CHECK

Identify classes	Install for Div./Group	Wire Special Occupancies	Select approved equipment		Perform residential checks	Commercial heat system	Commercial lights	Commercial electro mech.	Commercial ventilation	Commercial power system	Industrial HVAC	Industrial Machines	Industrial controls	Industrial power system	

51. OXYACETYLENE WELDING

Assemble oxyacetylene comp.	Prepare oxyacetylene unit	Connect proper tips	Run a bead	Make tack/butt weld	Make corner weld	Run bead with bronze	Use comparison guide	Make straight/level cuts	Cut holes	Welding/chemical					

52. ELECTRIC WELDING

Connect/set welder	Identify metals/select rod	Strike an arc	Tack/butt weld	Weld flat beads	Weld bat/fillet joints	Weld corner joints									

BIBLIOGRAPHY

TITLE	AUTHOR	PUBLISHER	DATE
A.C. Fundamentals	Duff	Delamr	1986
ANSI Standards	ANSI	ANSI	1987
American Electricians Hndbk.	Croft	Mc Graw Hill	1987
BOCA Basic Building Code	BOCA	BOCA Int.	1987
Basic Math For Elect/Electron.	Singer	Mc Graw Hill	1984
Connecticut Basic Bldg. Code		St. of Ct.	1987
D.C. Fundamentals	Loper	Delmar	1986
Electrical Const. Wiring	Alerich	Amer. Tech. Pub.	1979
Electrical Motor Control	Alerich	Delmar	1987
Electrical Motor Control	Rochis	Amer. Tech. Pub.	1987
Electrical Wiring Commerical	Millin and Smith	Delmar	1987
Electrical Wiring Industrial	Smith	Delmar	1987
Electrical Wiring Residential	Mullin	Delmar	1987
Electricity 1	Kubala	Delmar	1986
Electricity 2	Kubala	Delmar	1986
Electricity 3	Alerich	Delmar	1986
Electricity 4	Alerich	Delmar	1986
Electricity One-Seven	Mileaf	Hayden	1985
Electronics One-Seven	Mileaf	Hayden	1985
Electronics Principles/App.	Schuler, Charles	Mc Graw Hill	1979
Industrial Electricity	Nadon & Gelmine	Delmar	1983
Industrial Motor Control	Herman & Alerich	Delmar	1981
NEC Blueprint Reading	Gebert	Amer. Tech. Pub.	1987
National Electrical Code	NFPA 70	N.F.P.A.	1987
Product Directories U.L.	UL Lab.	U.L.	1987
Programmable Controllers Guide	Crx	Delmar	1983

ELECTRICAL APPRENTICE RELATED CURRICULUM

PREPARED BY EASTCONN
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PREPARED FOR:

CONNECTICUT STATE DEPARTMENT OF EDUCATION
DIVISION OF VOCATIONAL, TECHNICAL AND ADULT EDUCATION
VOCATIONAL-TECHNICAL SCHOOL SYSTEM
MIDDLETOWN, CONNECTICUT

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1989

08: Electrical

Apprentice Related Curriculum

First Year

1. A0001 Trade Math
2. A0031 Building Trades BPR
3. A0904 Electrical Code I
4. A0901 Electrical Theory I - DC

Second Year

1. A0905 Electrical Code II
2. A0032 Electrical Trade BPR-Industrial
3. A0902 Electrical Theory II - AC
4. A0002 Trade Math (Algebra)

Third Year

1. A0004 Trade Math (Trigonometry)
2. A0034 Electrical Trade BPR
3. A0906 Motor Controls
4. A0907 Motor and Generator Theory

Fourth Year

1. A0908 Semi-Conductor Theory
2. A0909 Electrical Code III
3. A0910 Electrical Code IV
4. A0917 Power Distribution

Fifth Year (Optional)

1. A0911 Construction Electrical Methods I
2. A0912 Construction Electrical Methods II
3. A0913 Industrial Semiconductors for Electricians
4. A0914 Logic Circuits for Electricians

GENERAL DESCRIPTION OF ELECTRICAL TRADE

Apprentice Component

The electrical trade is a licensed trade, and in order to be employed by an electrical contractor, an individual must hold a valid state license. A registered electrical apprentice with a valid identification card from the Labor Department may be employed and must follow a schedule of work processes in which the apprentice receives training and experience on the job. There is a progressively increasing schedule of wages in eight steps, one every 1,000 hours of completion culminating at the Journeyman rate. The period of training requires four years (8,000 hours) and is in two parts: 1) work training experience, and 2) related instruction.

Proper supervision of on-the-job training with adequate facilities to train apprentices is assured.

The apprentice's progress, both in job performance and related instruction, is evaluated periodically and appropriate records are maintained; successful completions are recognized and forwarded to the Labor Department Apprenticeship Division.

Related Component

The related training, 16 units of instruction, one unit representing 36 hours, is usually completed in 12 three-hour sessions for a total of 576 hours.

The objective of the program is to meet the requirements for achieving journeyman status and meeting the company's exact apprentice training requirements.

The related training is provided in the classrooms and shops of the Regional Vocational-Technical School System through lectures, discussions, use of models, visual aids, lab experiments, assignments, examinations and through the use of the vocational school equipment. The apprentice and related program is completed in a four-year period.

A0001 - TRADE MATHEMATICS

LENGTH: 36 Hours

DESCRIPTION: This course will enable students to solve problems involving angles, areas, weights, measures, rectangles, triangles, and volumes through the English and metric systems as these problems apply to the trade of their choice. It will also provide a review of basic arithmetic operations.

COMPETENCIES: The student will:

- solve problems with an accuracy of no less than seventy percent (70%)
- demonstrate basic mathematic operations
- apply English and metric systems to a variety of problems found in their trade.

I. Basic Operations - Review

   A. Real numbers
      1. addition
      2. multiplication
      3. subtraction
      4. division
   B. Fractions and decimal fractions
      1. addition
      2. subtraction
      3. multiplication
      4. division
      5. conversion from fractions to decimals
   C. Percentages and ratios
      1. theory and percentage
      2. computation of average
      3. computation of interest rates
      4. ratio and proportion
   D. Roots and squares
      1. of whole numbers
      2. of decimals
      3. of fractions
      4. use of handbook tables in terms of roots

II. Areas

   A. Squares and rectangles
   B. Triangles and irregular figures

III. Volumes

   A. Cubes and rectangles
   B. Cylinders
   C. Irregular shapes

IV. Charts and Graphs

   A. Types of graphs:
      1. bar
      2. linear
      3. circular
      4. interpreting graphs and charts from handbooks

V. Metric System

   A. Conversion from English to metric system
      1. linear measure
      2. square measure
      3. cubic measure

TEXTBOOKS: Applied General Mathematics. Robert D. Smith, Delmar Pub. Inc., 1984.

RESOURCES: Chalkboard lectures
Problems - worksheets
Homework - assignments
Testing
Flash cards

A0031 - BUILDING TRADES BLUEPRINT READING

LENGTH:	36 Hours
DESCRIPTION:	Provide the apprentice with the ability to interpret orthographic projections, isometric and detail drawings.
COMPETENCIES:	The student will be able to:

- o apply above skills to problems associated to their trade
- o read and interpret blueprints
- o perform above skills with an accuracy of no less than 70%.

I. Reading Drawings

- A. Pictorial drawings
- B. Perspective drawings
- C. Isometric drawings
- D. Oblique drawings
- E. Three-view drawings

II. Reading Elevation Drawings

- A. Design of building
- B. The roof
- C. Openings
- D. Dimensions
- E. Exterior finish
    - 1. materials
    - 2. trim
- F. Miscellaneous details

III. Reading Floor Plans

- A. Importance
- B. Basic ideas in reading plans
- C. Reading floor plans
    - 1. one-story house
    - 2. two-story house
    - 3. one-and-one-half-story house

IV. Symbols and Notations

- A. Materials
- B. Building parts

V. Scaling and Dimensional Practices

- A. The architect's scale
- B. Reading a scale
- C. Measuring blueprints
- D. Drawing symbols or conventions to scale
- E. Dimensioning standards
    - 1. exterior walls
    - 2. interior partitions
- F. Dimensioning methods
- G. Windows and doors

VI. Reading Blueprints for Structural Information

A. Construction types
B. Platform framing
C. Balloon framing
D. Plank and beam framing
E. Brick veneer construction
F. Masonry buildings
G. Unit construction
H. Prefabricated houses

VII. Reading Detail Drawings

A. Dimensions
B. Locating detail
C. Details of interior wall elevations
D. Details of the structure
E. Window and door details
F. Details of trim
  1. exterior
  2. interior

VIII. Reading Blueprints for Trade Information

A. Types of trade information
B. Division of labor
C. Specifications
D. Modular and component concepts
E. Electrical work
F. Plumbing
G. Sheet metal
H. Heat and air conditioning
I. Concrete work and masonry
J. Welding

TEXTBOOKS: Building Trades Blueprint Reading, 5th Edition, Part 1 Fundamentals. E.W. Sundberg, American Technical Publishers Inc., 1987.
Basic Construction Blueprint Reading. Mark W. Huth, Delmar Publishers Inc., 1989.

RESOURCES: Chalkboard lectures
Scaling and dimensional practice
Reading actual blueprints
Testing

A0904 - ELECTRICAL CODE I

LENGTH: 36 Hours

DESCRIPTION: The student will use technical terms to applying wiring methods and design.

COMPETENCIES: The student will be able to:

- understand the importance of safeguarding persons and property from hazards arising from electricity usage
- easily find the requirements for electrical installations
- compute feeder and service loads.

I. General

  A. Definitions
  B. General requirements

II. Wiring Design and Protection

  A. Branch circuits
  B. Feeders
  C. Calculations
  D. Services

III. Wiring Method and Materials

  A. Temporary wiring
  B. Supports
  C. Types of cable
    1. use of
  D. Rigid conduit
    1. metallic
    2. non-metallic
  E. Raceways
    1. floor
    2. structural
  F. Wireways
  G. Outlet switch and junction boxes
  H. Switchboard and panel boards
  I. Prefabricated buildings

TEXTBOOKS: National Electrical Code Book, 1987 Edition. National Fire Protection Association, Quincy, Mass. 02269, 1987.
1987 Changes of the 1987 Electrical Code. James Stallcup, American Technical Publishers, 1987.

RESOURCES: Chalkboard lectures
Code discussions (common problems)
Assignments
Testing
Class participation in looking up requirements

A0901 - ELECTRICAL THEORY I

LENGTH:	36 Hours
DESCRIPTION:	This course will provide the student with the basic principles or direct current, such as electron theory, flow of electrons, Ohm's Law and magnetism.
COMPETENCIES:	The student will:

- solve direct current problems using Ohm's Law.
- compute wire sizes from the AWG table.
- measure current, volts, and amperes in DC circuits.
- read electrical schematics containing batteries, switches, resistances and relays.

I. Matter

A. Structure of matter
B. Elements, compounds, and mixtures
C. Atoms, molecules, subatomic particles, electron theory
D. Electrons - orbits and shells
E. Law of electrostatic charges
F. The electroscope
G. Static electricity
H. Means of producing electricity
    1. friction - static
    2. chemical
    3. heat
    4. light
    5. pressure
    6. magnetism

II. Electrical Units

A. Voltage
B. Current
C. Resistance
D. Electrical symbols
E. Ohm's Law
F. Series and parallel circuits
G. Measuring devices

III. Power and Energy

A. Unit of power
B. Power formulas
C. Kilowatts and horsepower
D. Work
E. Heat
F. Computation of power

IV. Wire

- A. Sizes
- B. Circular measure
- C. Ampacity
- D. AWG tables
- E. Insulation

V. Magnets and Magnetism

- A. Flow of magnetic lines
- B. Reluctance
- C. Thumb rule for coil
- D. Permanent and artificial magnets

VI. Electromagnetism

- A. Electromagnetic induction
- B. Left hand rule
- C. Basic generator
- D. DC - AC
- E. Basic motor

TEXTBOOKS: Basic Electronics. Bernard Grob, McGraw Hill Pub., 1989.
Direct Current Fundamentals, 3rd Edition. Loper and Tedson, Delmar Pub. Inc., 1985.

RESOURCES: Chalkboard lecture
Audio visual aids; filmstrips
Problem solving (math)
Assignments
Testing
Lab demonstrations

A0905 - ELECTRICAL CODE II

LENGTH:	36 Hours
DESCRIPTION:	This course is designed to teach the student types of equipment, its proper use and calculation.
COMPETENCIES:	The student will select appropriate types of equipment, use them, and make necessary calculations.

I. Equipment for General Use

   A. Flexible cord and cables
   B. Fixture wires
   C. Appliances
   D. De-icing and snow melting equipment
   E. Motor circuit and controls
   F. Air conditioning and refrigeration
   G. Motor circuit calculations
   H. Transformer and transformer vaults
   I. Resistors and reactors
   J. Storage batteries

II. Special Occupancies

   A. Hazardous locations
      1. Class I
      2. Class II
      3. Class III

III. Specific Locations

   A. Commercial garages
   B. Residential
   C. Aircraft hangars
   D. Gasoline dispensing
   E. Bulk storage
   F. Health care facilities
   G. Theatre and assembly halls
   H. Finishing processes
   I. Motion pictures
      1. studios
      2. projectors
      3. developing room
   J. Mobile homes
   K. Mobile parks
   L. Marina and boat yards

TEXTBOOKS: _National Electrical Code Book, 1987 Edition_. National Fire Protection Association, Quincy, Mass. 02269, 1987.
1987 Changes of the 1987 Electrical Code. James Stallcup, American Technical Publishers, 1987.

RESOURCES: Chalkboard lectures
Code discussions (common problems)
Assignments
Testing
Practice looking up regulations

A0032 - ELECTRICAL TRADE - Blueprint Reading--Industrial

LENGTH:	36 Hours
DESCRIPTION:	This course is designed to provide the student with drawing skills and practices, and the interpretations of terms, symbols and standards as they apply to commercial, residential and industrial drawings and diagrams. The student will be able to perform these skills with an accuracy of no less than seventy percent (70%).
COMPETENCIES:	The student will be able to:

- o identify electrical symbols commonly used
- o read and interpret wiring diagrams
- o identify all parts of a service entrance
- o draw a start-top motor control diagram.

I. Electrical Circuits

- A. Electrical symbols
- B. Schematic diagrams
- C. Wiring diagrams
  - 1. residential
  - 2. industrial
  - 3. communication circuits
- D. General survey of electrical circuits

II. Residential, Commercial and Industrial

- A. Outlets
- B. Switches
- C. Weatherproof outlets
- D. Power panels
- E. Thermostats

III. Electrical Layouts and Equipment

- A. Layouts
- B. Panel layouts
- C. Switchboard layouts
- D. Motors and controls
- E. Service entrance and metering facilities

IV. Code

- A. Wiring methods and materials
  - 1. outlets, devices, junction boxes
- B. Switches
  - 1. installation, construction

TEXTBOOKS: National Electrical Code Book, 1987 Edition. National Fire Protection Association, Quincy, Mass. 02269, 1987.
1987 Changes of the 1987 National Electrical Code. James Stallcup, American Technical Publishers, 1987.

RESOURCES: Chalkboard lectures
Code discussions (common problems)
Assignments
Testing
Practice looking up regulations

A0902 - ELECTRICAL THEORY II - AC

LENGTH: 36 Hours

DESCRIPTION: This course is designed to provide the student with the skills of drawing practices; and the interpretations of terms, symbols and standards as they apply to commercial, residential and industrial drawings and diagrams. The student will be able to perform these skills with an accuracy of no less than seventy percent (70%).

COMPETENCIES: The student will be able to:

- understand the generation of alternating current
- solve R-L circuit problems (math calculations)
- calculate transformer voltages and currents.

I. AC Fundamentals

A. Generation of the sineware
   1. Lenz's Law
   2. left hand rule for a conductor
   3. factors needed to generate voltage
   4. factors for determining the strength of induced E.M.F.
   5. terms

B. Cycle, alteration, period
C. Frequency, hertz, wave length
D. Instantaneous, peak, peak to peak, r.m.s., and average values
E. Phase angle

II. Inductance

A. Induction by A.C.
B. Lenz's Law
C. Impedance and resistance
D. Inductance in series, and in parallel
E. Mutual inductance
F. R.L. circuits, series, and parallel
G. Power factor
H. Transformers
   1. operation
      a. step-up
      b. step-down

III. Problem Solving

A. Trigonometry
   1. right angle
      a. functions
      b. solving problems
         1. x, r and z

B. AC characteristics
    1. series RL circuits
    2. series RC circuits
    3. parallel RL circuits
    4. parallel RC circuits
    5. LC circuits
    6. series LCR circuits
    7. parallel LCR circuits

IV. Power in AC Circuits

A. Power factor
    1. corrections
    2. power factor problems

V. Florescent Lighting

A. Principles
B. Wiring
C. Power factor

TEXTBOOKS: Basic Electronics. Bernard Grob, McGraw-Hill Publishers, 1989.
Alternating Current Fundaments, 3rd Edition. Duff and Herman, Delmar Publishers, Inc., 1985.

RESOURCES: Chalkboard lectures
Audio visual aids; filmstrips
Assignments
Math calculations
Testing
Lab demonstration

AQ002 - TRADE MATHEMATICS

LENGTH:	36 Hours
DESCRIPTION:	This course will provide the student with the necessary skills to perform addition, subtraction, multiplication and addition of algebraic functions including fractions and the application of these techniques to the transposition of formulas and the solution of trade problems. The student will perform these skills with an accuracy of no less than seventy percent (70%).
COMPETENCIES:	The student will be able to:

- o solve algebraic equations
- o transpose equations used in their trade
- o solve word problems.

I. Formulas

- A. Transposition of simple formulas
  - 1. balancing the formula
- B. Application of formulas to problems

II. Algebraic Fundamentals

- A. Concepts
  - 1. positive and negative numbers
  - 2. addition, multiplication and division of Algebraic expressions

III. Equations

- A. One unknown
  - 1. solutions through addition, subtraction, multiplication and division
- B. Exponents
  - 1. solutions through addition, multiplication, subtraction and division of exponents
- C. Factoring
  - 1. reduction of fractions
  - 2. change mixed numbers to improper fractions

TEXTBOOKS: Fundamentals of Electronics Mathematics. Carl Rader, Delmar Publishers Inc., 1985.
Modern Electronics Mathematics. Richard L. Sullivan, Delmar Publishers Inc., 1985.

RESOURCES: Chalkboard lectures
Problems - worksheets
Homework - assignments
Testing

A0004 - ELECTRICAL TRADE MATHEMATICS

LENGTH: 36 Hours

DESCRIPTION: This course will provide the student with the skills to apply trigonometric tables, and functions to the solution of trade problems involving right triangles.

COMPETENCIES: The student will be able to:

- apply trigonometry in solving alternating current problems
- calculate elevations and depressions encountered with their trade.

I. Principle of Trigonometry

- A. Review of construction of triangles
    1. pythagorean theorem
    2. rectangular coordinates
    3. measurement of angles

II. Trigonometric Functions

- A. Sine, cosine, tangent, cotangent
    1. ratios (mathematical)
    2. tables (handbook)
    3. secant, cosecant

III. Solution of Problems

- A. Graphic method
- B. Computing unknown from known elements
    1. given an acute angle and one side not the hypotenuse
    2. given an acute angle and the hypotenuse
    3. given the hypotenuse and one other side
    4. given two sides not the hypotenuse

IV. Terms Related to Miscellaneous Trigonometry Problems

- A. Angle of elevation
- B. Angle of depression
- C. Horizontal distance
- D. Vertical distance

V. Area of Triangles

TEXTBOOKS: Fundamentals of Electronics Mathematics. Carl Rader, Delmar Publishers Inc., 1985.
Modern Electronics Mathematics. Richard L. Sullivan, Delmar Publishers Inc., 1985.

RESOURCES: Chalkboard lectures
Problems - worksheets
Homework
Assignments
Testing

A0034 - ELECTRICAL TRADE BPR

LENGTH: 36 Hours

DESCRIPTION: This course is designed to provide the Electrical student with the skill to interpret Electrical symbols, and a thorough knowledge of the significance of these symbols in the reading of electrical controls. The student should be able to perform these skills with an accuracy of no less than seventy percent (70%).

COMPETENCIES: The student will be able to:

- o understand the basic principles of DC and AC motors
- o draw a wiring diagram of a motor reversing circuit
- o understand power distribution systems.

I. Motor Diagrams AC and DC

- A. 2 wire D.C. Generators
- B. 3 wire D.C. Generators
- C. Direct - current motors
  - 1. shunt
  - 2. series
  - 3. compound
- D. Alternative current
  - 1. single phase
  - 2. two phase
  - 3. three phase

II. Symbols for Control Diagrams

III. Motor Control Diagrams

- A. Across the line starters
- B. Schematic
- C. Reversing motor equipment

IV. Special Equipment

V. Code (As Applied)

- A. Motors, motor circuits
- B. Controllers
- C. Motor control circuits

TEXTBOOKS: Electrical Motor Controls Workbook, 2nd Edition. Rockis and Mazur, American Technical Publishers Inc., 1987.
Electric Motor Controls, 2nd Edition. Rockis and Mazur, American Technical Publishers Inc., 1987.

RESOURCES: Chalkboard lectures
Wiring diagrams
Lab: Hookup of motor control circuits
Assignments
Testing

A0906 - MOTOR CONTROLS

LENGTH:	36 Hours
DESCRIPTION:	This course will enable the apprentice to recognize all symbols used in control circuits; trace out schematic diagrams of circuits as to their function and purpose and determine malfunctions.
COMPETENCIES:	The student will be able to:

- o understand and read line diagrams and wiring diagrams
- o interpret and read Industrial Electrical symbols
- o analyze and troubleshoot control circuits.

I. Fundamentals

- A. What it is
- B. Different methods
- C. What switching is

II. Controllers and their Functions

- A. Controller types
- B. Controller sizes

III. Pilot Devices

- A. Push buttons
- B. Relays and controllers
- C. Float and pressure switches
- D. Limit switches
- E. Mechanical and electrical interlocking

IV. Symbols and Diagrams

- A. Industrial electrical symbols
- B. Line diagrams
- C. Wiring diagrams

V. Control Circuits

- A. Language of control
- B. Manual control circuits
- C. Automatic control circuits
- D. Magnetic control
    1. solenoids
    2. contactors
    3. magnetic motor starters

E. Basic control circuits
    1. multiple station
    2. sequential control
    3. reversing
    4. jogging
    5. time delay

VI. Developing Control Circuits

VII. Control Circuit Analysis

VIII. Troubleshooting

IX. Types of Reduced Voltage Starting

A. Primary resistance
B. Autotransformer
C. Star Delta

X. Introduction to Programmable Controllers

A. Input/output (I/O) section
B. Processing unit
C. Numbering systems
D. Application

TEXTBOOKS: Electrical Motor Controls, 2nd Edition. Rockis and Mazur, American Technical Publishers Inc., 1987.
Electrical Motor Controls Workbook, 2nd Edition. Rockis and Mazur, American Technical Publishers Inc., 1987.

RESOURCES: Chalkboard lectures
Assignments
Testing
Lab: Motor control circuit wiring
    1. line diagrams
    2. wiring diagrams
Demonstration of programmable controllers

A0907 - MOTOR AND GENERATOR THEORY
Review AC Generation; the Sine Ware

LENGTH: 36 Hours

DESCRIPTION: This course will teach the student the operating characteristics of AC and DC Motor and Generator operation.

COMPETENCIES: The student will be able to:

- clarify motors and generators to their types and uses
- calculate motor circuits
- identify the proper motor to be used for each application.

I. The Simple DC Motor

   A. Motor action
   B. Motor torque
   C. Field strength
   D. Counter EMF
   E. Motor speed
   F. Percent of regulation

II. Series, Shunt and Compound Motors

   A. DC motor starters
   B. Magnetic starting switch

III. Universal Motors

IV. AC Motor Theory

   A. Left-hand conductor rule
   B. Motor action
   C. Right-hand rule for motors

V. Alternating-Current Motors

   A. Polyphase motors
      1. the induction motor
         a. squirrel cage rotor
         b. wound rotor

VI. Induction Motor Speed

VII. Single-Phase Motors

   A. Construction
   B. Split-phase motors
   C. Capacitor-start motors
   D. Shaded-pole motors

VIII. Circuit Calculations - Motor Circuits

- A. Determine branch circuit conductors and feeders
- B. Code tables - motor name plates
- C. Codes
- D. Conduit tables - derating - correction factor
- E. Calculate motor loads
- F. Project:
  1. industrial power applications
  2. calculate motor loads
  3. service calculations

TEXTBOOKS: Electricity 3: Motors and Generators, Controls, Transformers, 4th Ed. Walter N. Alerich, Delmar Publishers Inc., 1986.
Motors and Transformers. James G. Stallcup, American Technical Publishers Inc., 1987.

RESOURCES: Chalkboard lecture
Assignments
Testing
Visual aids: photos
worksheets
filmstrips
Lab: operation of motors and generators

A0908 - SEMICONDUCTOR THEORY FOR ELECTRICAL

LENGTH:	36 Hours
DESCRIPTION:	This course will enable the student to recognize semiconductor devices both schematically and physically; also he/she will be able to recognize schematically their use and purpose, and will be able to troubleshoot a static control circuit.
COMPETENCIES:	The student will be able to:

- understand the principles of semiconductor operation
- differentiate between NPN and PNP devices
- troubleshoot SCR on Triac control circuits.

I. Semiconductors

A. Atomic structure of material
B. Types of material
    1. doping
    2. N type
    3. P type
    4. current carriers
C. PN junction characteristics

II. Diodes

A. Conventional rectifier
    1. ideal diode
    2. bridge networks
B. Zener diode
    1. characteristic curve
    2. uses
    3. regulators
C. Varistor and thermistor
D. LED

III. Transistors

A. Types
    1. PNP
    2. NPN
B. Amplifier types
    1. common base
    2. common emitter
    3. common collector
C. Switching transistors
    1. two state devices
D. Circuit analysis
    1. schematic analysis of amplifier
    2. oscillators

IV. Silicon Control Rectifiers

- A. Principle of operation
- B. Construction
- C. Types and uses
- D. Methods of turning off and on
- E. Switching AC and DC voltages
- F. Uses in motor controls

V. Other Semiconductor Devices

- A. DIAC
- B. TRIACS
- C. Unijunction transistors

VI. Logic Circuits

- A. "Or" gate
- B. "Nor" gate
- C. "And" gate
- D. "Nand" gate
- E. Applications

TEXTBOOKS: Electronics, Principles and Applications, 2nd Edition. Charles A. Schuler, McGraw-Hill Co., 1989.

RESOURCES: Chalkboard lectures
Lab demonstrations in electronics shop
1. oscilloscope operation
2. diac and SCR experiments
3. power supply circuits
Assignments
Testing

A0909 - ELECTRICAL CODE III

LENGTH: 36 Hours

DESCRIPTION: To teach the student the proper method of installing electrical wiring and understand the installation of special equipment.

COMPETENCIES: The student will be able to:

- understand the regulations regarding low voltage systems
- understand the code requirements of specialized equipment
- calculate branch feeder circuits.

I. Special Equipment

A. Electric signs
B. Outline lighting
C. Cranes and hoists
D. Elevators, dumb waiters and escalators
E. Data processing
F. Organs
G. X-ray equipment
H. Heating equipment
I. Machine tools
J. Swimming pools and wading pools

II. Special Conditions

A. Emergency systems
B. Over 600 volts
    1. general
    2. specific
C. Less than 50 volts
D. Remote control
    1. low energy power
    2. low voltage
    3. power and signal circuit

III. Outside Branch Circuits and Feeders

IV. Power Generator Systems

V. Communications Systems

A. Circuits
B. Radio and T.V. equipment
C. Community antenna and T.V.
D. T.V. and radio distribution systems

VI. Table Calculations

- A. Ampacity limits
- B. Maximum number of conductors
  - 1. in conduit
  - 2. in tubing
- C. Conductor properties

TEXTBOOKS: 1987 National Electrical Code Book. National Fire Protection Association, Quincy, Mass., 1987.

RESOURCES:
Chalkboard lectures
Quiz
Assignments
Testing
Discussions
Referral to code books

A0910 - ELECTRICAL CODE IV

LENGTH: 36 Hours

DESCRIPTION: To teach the student the National Electrical Code, its application, design and calculate circuits in preparation for State Journeyman's Electrician's License.

COMPETENCIES: The student will be able to:

- o pass the exam for the State Journeyman's Electrician's License.

I. Chapters I, II, III - National Electrical Code

A. Questions, problems
B. Testing
C. Coordinate review, supplemented by questions and problems

II. Chapters IV and V

A. Questions, problems
B. Testing
C. Coordinate review, supplemented by questions and problems

III. Chapters VI, VII, VIII

A. Questions, problems
B. Testing
C. Coordinate review, supplemented by questions and problems

IV. Final Testing

All Chapters

TEXTBOOKS: 1987 National Electrical Code Book. National Fire Protection Association, Quincy, Mass., 1987.

RESOURCES: Written test
1987 Code Book
Review

A0917 - POWER DISTRIBUTION

LENGTH: 36 Hours

DESCRIPTION: This course will enable the apprentice to calculate voltage drop for single-phase and three-phase systems, also calculate wire size used for long runs to various loads. The student should be able to check out polarity of transformers; calculate voltage and current ratios of single and poly-phase systems and recognize the difference between power systems used in electrical distributions. The student will be able to correct the power factor of any poly-phase motor from 1/2 HP to 200 HP by using a clamp-on ammeter.

COMPETENCIES: The student will be able to:

- o safely connect high voltage transformers
- o calculate for power factor correction
- o understand power transformation.

I. Voltage Drop Calculations and Wire Size

  A. Calculate voltage drop
  B. Calculate wire size
  C. Problems involving all types of loads

II. Fundamentals

  A. Principles of transformers
  B. Ratios, voltage, current and power in transformers
  C. Transformer calculations
  D. Checking the phase and polarity of transformers

III. Two-Phase Systems

  A. Two-phase transformation
  B. Two-phase Scott connection
  C. Calculating neutral conductor on a two-phase 5 wire system

IV. Three-Phase Systems

  A. Reason for three-phase systems used in distribution
  B. Different types of three-phase systems
  C. Transformer connections used for different voltages
  D. Power output calculations of transformers

V. Power-Factor Correction

  A. Power-factor fundamentals
  B. Power-factor of various three-phase motors
  C. Calculations for sizing capacitors needed for power-factor correction of poly-phase motors

TEXTBOOKS: Transformers, 2nd Edition. Gebert and Edwards, American Technical Publishers Inc., 1986.

RESOURCES: Chalkboard lectures
Discussions
Mathematical calculations
Assignments
Testing

A0911 - CONSTRUCTION ELECTRICIAN METHODS I

LENGTH:	36 Hours
DESCRIPTION:	This course will enable the apprentice to select and use the proper equipment for the job that he/she has to perform.
COMPETENCIES:	The student will:

- use tools and equipment properly
- calculate wiring installations correctly
- be knowledgeable about all types of switches.

I. Tools

- A. Hand tools
- B. Hand and hydraulic benders
- C. Power tools
- D. Knockouts - hand and power
- E. Care and maintenance

II. Switches

- A. Poles
- B. Normally open/normally closed
- C. Operation of switches and relays

III. Fastening Devices

- A. Nails
- B. Screws, wood, machine
- C. Electrical
- D. Machine bolts and nuts
- E. Toggles
- F. Anchors
- G. Shields
- H. Rawls

IV. Wiring Devices

- A. Receptacles
- B. Caps
- C. Boxes
- D. Box covers
- E. Flush plates
- F. Hangers
- G. Floor boxes
- H. Pull boxes
- I. Box holders

V. Requirements for Wiring Installations

A. Conductor sizes
B. Protection
C. Rating of protective devices
D. Grounded conductors
E. Ground fault circuit interrupters
F. Splicing
G. Outlets
H. Accessories
I. Lighting fixtures
J. Calculations of number of conductors

TEXTBOOKS: 1987 Electrical Code Book. National Fire Protection Association, Quincy, Mass., 1987.
Electrical Motor Controls. Rockis and Mazur, American Technical Publishers Inc., 1987.

RESOURCES: Lab: Electrical shop tools demonstration
Chalkboard lectures
Testing
Discussions

A0912 - CONSTRUCTION ELECTRICIAN METHODS II

LENGTH: 36 Hours

DESCRIPTION: This course will enable the apprentice to use the National Electrical Code Handbook to solve problems in selecting the right components for a job; or to meet standards in performing electrical work. Also, he will be able to select the right components for lighting circuits.

COMPETENCIES: The student will be able to:

- install lighting circuits efficiently
- calculate lumen levels
- understand code requirements for lighting.

I. National Electrical Code

- A. Introduction (Article 90)
- B. Definitions
- C. Enforcement
- D. Wiring methods
- E. Grounding
- F. Overcurrent protection

II. Illumination

- A. Incandescent lamps
  - 1. construction
  - 2. characteristics
  - 3. types
- B. Florescent lamps
  - 1. construction
  - 2. characteristics
  - 3. starter types
  - 4. power factors
- C. Lighting design
  - 1. quality of light
  - 2. candlepower
  - 3. lumens
  - 4. diffusion
  - 5. choice of lights
- D. Procedure in calculating lumen level
- E. Home lighting
  - 1. outdoor
  - 2. entrance
  - 3. halls
  - 4. kitchen - dining - living room
  - 5. National Electrical Code requirements

TEXTBOOKS: 1987 Electrical Code Book. National Fire Protection Association, Quincy, Mass., 1987.

RESOURCES: Referral to code book
Discussion
Assignments
Testing

A0913 - INDUSTRIAL SEMICONDUCTION FOR ELECTRICIANS

LENGTH: 36 Hours

DESCRIPTION: This course will enable the student to recognize both schematically and physically; he/she will be able to recognize their use and purpose and will be able to troubleshoot a static control circuit.

COMPETENCIES: The student will be able to:

- o efficiently utilize solid state devices
- o understand industrial solid state controls
- o troubleshoot Triac and SCR circuits.

I. Full-wave Power Supplies

  A. Standard
  B. Bridge rectifier
  C. Regulation

II. Switch Types

  A. Transistor
  B. PNPN
  C. SCR

III. SCR Rectifier Control Switch

IV. RC Phase Shift

V. Phase Shift SCR Control

VI. SCR Static Control

VII. Unijunction Transistors

  A. Operation
  B. Sweep circuit
  C. SCR control circuit

VIII. Diacs

  A. Operation
  B. Characteristics

IX. Triac

  A. Operation
  B. Phase shift control
  C. Latching and holding circuits (currents)

X. Astable Multivibrator (Digital)

XI. Series Voltage Control (Digital)

XII. Photocell SCR Control

XIII. Transformers

   A. Step-Up
   B. Autotransformer
   C. Two transformer inverter
   D. Transformer inductance

XIV. Converters

   A. Ringing - choke
   B. D.C. to A.C.
   C. D.C. to D.C.

XV. A.C. Magnetic Amplifier

   A. Operation

XVI. D.C. Magnetic Amplifier

XVII. Full-wave SCR Bridge

TEXTBOOKS: Electronics, Principles and Applications, 2nd Edition. Charles A. Schuler, McGraw-Hill Co., 1989.

RESOURCES: Chalkboard lectures
Assignments
Testing
Audio visual aids
   1. film strips
   2. video tapes
Lab experiments in electronics shop
   1. oscilloscope waveforms
   2. triac and SCR control circuits

A0914 - LOGIC CIRCUITS FOR ELECTRICIANS

LENGTH: 36 Hours

DESCRIPTION: This course will enable the student to recognize logic symbols and schematically trace out data flow through logic circuits such as AND, OR, Inverters, counters, and adders.

COMPETENCIES: The student will be able to:

- understand digital control circuits
- wire logic gates
- construct truth tables.

I. Arithmetic for Static Controls

    A. Natural binary numbers
    B. Octal numbers
    C. Binary coded decimal

II. Logic Gates

    A. AND gate
    B. OR gate
    C. NOR gate
    D. NAND gate

III. Boolean Algebra

    A. Boolean expressions
    B. Laws and theorems
    C. Circuit expressions

IV. Special Circuits

    A. Parity
    B. Adders

V. Counting Circuits

    A. Types of flip flops
    B. Counters
        1. ripple
        2. decade
        3. shift registers

VI. Pulse Forming Circuits

VII. Static Controls

A. Schematic interpretation
B. Troubleshooting schematically

TEXTBOOKS: Electrical Motor Controls, Automated Industrial Systems, 2nd Edition. Rockis and Mazur, American Technical Publishers Inc., 1987.
Digital Systems. Ronald J. Tocci, Prentice-Hall, Inc., 1985.

RESOURCES: Lab: Digital experiments - Electronics lab
1. logic gates
2. pulse forming circuits
3. adders, counters
Chalkboard lectures
Assignments
Testing